IMPROVEMENT OF PLASMA PERFORMANCE BY EDGE ECRH POWER DEPOSITION IN EAST

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1. ABSTRACT

Edge electron cyclotron resonance heating (ECRH) has been observed to enhance plasma performance in the EAST tokamak. By adjusting the ECRH mirror, the power was shifted from the core to the edge plasma during H-mode operation. Following this edge ECRH deposition, the plasma density profile flattened, while the profiles for both electron and ion temperatures became steeper. Additionally, the tungsten content decreased, indicating improved plasma cleanliness. Observations revealed that the turbulence intensity in the core plasma gradually diminished, with the turbulence propagation velocity directed toward the ion diamagnetic direction, suggesting the presence of ion temperature gradient (ITG) turbulence. This reduction in turbulence correlates with an evolved safety factor profile that transitioned to exhibit negative magnetic shear after the edge ECRH deposition, thereby facilitating the suppression of ITG turbulence.

2. INTRODUCTION

Currently, ECRH heating plays a dominant role in ITER and future fusion devices. Unlike other auxiliary heating systems, such as LHCD, NBI, and ICRF, ECRH can efficiently deposit energy into the plasma core while hardly interact with the boundary plasma, thus reducing the impact on plasma-wall interactions. However, as the toroidal magnetic field increases in future fusion devices, a higher ECRH gyrotron frequency will be required to effectively deliver power to the core plasma, which will consequently increase costs. Several tokamaks, including AUG [1], TCV [2], and DIII-D [3], have conducted experiments focused on ECRH edge power deposition, but unfortunately, these efforts have often led to a deterioration in plasma confinement as ECRH power was shifted to the edge. This presentation reports on a promising edge ECRH power deposition experiment conducted at EAST, where an improvement in plasma confinement and a reduction in tungsten content were achieved.

3. EXPERIMENTAL SETUP

ECRH has been deposited at ρ ~ 0.4 and ρ ~ 0.8, as illustrated in Fig. 1. Following the edge ECRH deposition, both edge and core plasma densities gradually decreased, while the plasma electron and ion temperatures, as well as the stored plasma energy, gradually increased. Moreover, the plasma density gradient decreased, accompanied by an increase in the temperature gradients of both electron and ion. These changes contributed to a reduction in tungsten concentration by lowering its neo-classical pitch velocity.

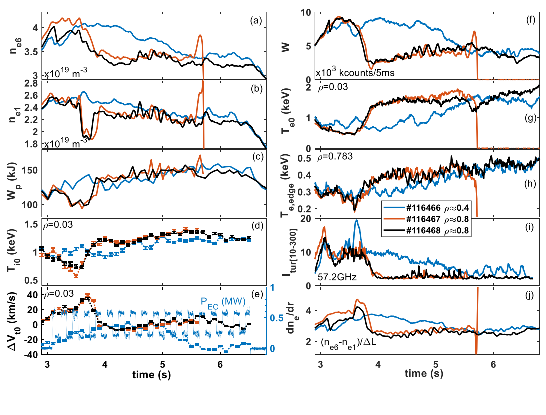

Fig. 1 edge ECRH power deposition experiment

A low-frequency wideband turbulence has been measured by the PCR diagnostic. Following the ECRH edge deposition, the turbulence intensity gradually decreased. Since each frequency in PCR encompasses two elements spaced ~1.9cm apart poloidally, this allows for the measurement of the turbulence wavenumber. The wavenumber as a function of turbulence frequency indicated that the wideband turbulence propagated in the ion diamagnetic direction, suggesting that its characteristics are consistent with ion temperature gradient (ITG) turbulence.

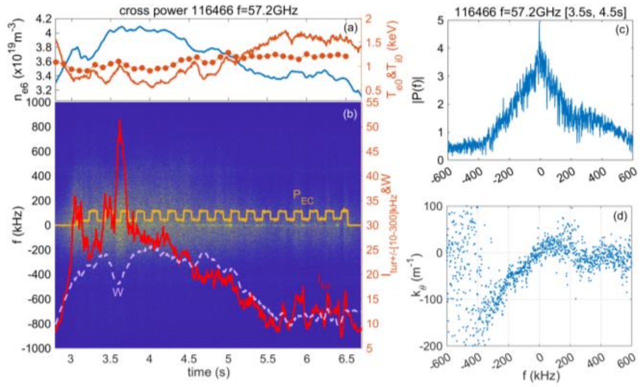

Fig.2 turbulence reduction measured by PCR diagnostic

4. CONCLUSION

In summary, the edge ECRH power deposition experiment has been observed to improve plasma performance in the EAST tokamak. During LHCD and NBI heating in H-mode plasma, 0.6 MW of ECRH power, modulated at 5 Hz and 10 Hz, was deposited from the core ($\rho \sim 0$) to the edge ($\rho \sim 0.8$) by adjusting the ECRH mirror. The ECE diagnostic measured the perturbed temperature profiles, with the maximum values correlating with the ECRH deposition settings. Following the edge ECRH deposition, both plasma density and tungsten impurity levels gradually decreased, whereas plasma electron and ion temperatures, as well as stored plasma energy, gradually increased. Additionally, the plasma density profile was flattened, while the profiles for both electron and ion temperatures became steeper. These changes contributed to reducing the neo-classical pitch velocity of tungsten, even reversing its direction toward the outside. The PCR diagnostic indicated that turbulence intensity in the core plasma gradually decreased, with turbulence propagation directed toward the ion diamagnetic direction, suggesting the presence of ion temperature gradient (ITG) turbulence. This reduction in turbulence is correlated with an evolved safety factor profile, estimated by POINT, that transitioned to exhibit negative magnetic shear after the edge ECRH deposition, thus facilitating the suppression of ITG turbulence. These findings may help extend the operational range of ECRH in future high toroidal magnetic field devices.

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